The Met Office Hadley Centre Climate Programme: Driving Climate Science for a Resilient Future

Description

As the climate we live in changes, there is an ever-growing need for climate information to aid resilience, adaptation, and mitigation planning both in the UK and globally.

Established in 1990, the Met Office Hadley Centre for Climate Science and Services is one of the world's leading climate science institutions. Pioneering research carried out with global partners has been instrumental in helping the UK and other nations understand and address the challenges posed by climate change.

The Met Office Hadley Centre Climate Programme stands at the forefront of global climate research, providing crucial research which informs both national and international climate policies. This blog explores the pivotal role of the Met Office Hadley Centre Climate Programme in providing climate evidence to numerous UK Government departments as well as its broader benefits to society.

The Role of the Climate Programme across Government Departments

The Met Office Hadley Centre Climate Programme contributes to underpinning climate science research in the UK, meeting UK Government evidence needs and supporting the UK and global climate community to understand and respond to climate challenges.

Funded by the Department for Science, Innovation and Technology and managed by the Department for Energy Security and Net Zero, Department for Environment, Food & Rural Affairs and the Foreign, Commonwealth & Development Office, the Climate Programme delivers immediate impact and value by developing core climate science capability (through modelling, data and infrastructure) and by delivering scientific knowledge and expertise.

Supporting resilience, adaptation and mitigation planning

The UK Climate Projections (UKCP) are a set of tools and data showing how the UK climate is changing and may change in the future. They are particularly significant for downstream users of climate information in Government and industry to aid resilience and adaptation.

In July 2023, Defra launched the Third National Adaptation Programme (NAP3) which sets out a 5-year programme of action to build the UK's resilience to climate change. It is part of the statutory process set out under the Climate Change Act, 2008 and includes existing, strengthened, and new commitments to respond to the 61 risks and opportunities identified in the UK's Third Climate Change Risk Assessment (CCRA3).

Science evidence both provided by and underpinned by the Climate Programme played a vital role in informing CCRA3 and the adaptation actions set out in NAP3. The UKCP projections were a key source of information for both the third CCRA and NAP3. They underpin much of the adaptation work taking place in the UK and provide evidence on climate hazards we could experience at 2°C and 4°C of warming.

Energy security and resilience

The Department for Energy Security and Net Zero (DESNZ) plays a critical role in the UK's response to climate change, with a focus on transitioning to sustainable energy and reducing greenhouse gas emissions. The Met Office Hadley Centre Climate Programme, contributes to the scientific foundation needed to support these objectives. By delivering high-quality climate science and modeling, essential for developing robust policies, DESNZ ensures energy security while advancing the UK's sustainability goals.

In a recent blog we shared how we are supporting the energy sector better understand the energy needs for the 2030's and beyond. Working with Ofgem, DESNZ, the Climate Change Committee (CCC) and the electricity system operator (ESO), our aim is to make data sets and guidance available for use by the entire energy sector. This initiative seeks to provide consistency, reduce duplication, and lower costs across various projects and research efforts exploring future energy models and needs.

Energy security is a key priority for Government. Winter weather in the UK and its associated impacts are strongly correlated to the large-scale atmospheric circulation in the North Atlantic region. The Met Office seasonal forecasting system, underpinned by the Climate Programme can skilfully predict this large-scale circulation in winter, which enables skilful seasonal climate forecasts for the energy sector. This supports UK energy resilience by of high-risk periods for energy demand and supply, for example in winter cold snaps and wind droughts.

Through its cutting-edge research, the Climate Programme informs DESNZ strategies on energy

resilience, adaptation to climate impacts, and the development of low-carbon technologies. This collaboration ensures that the UK's energy policies are grounded in the latest scientific evidence, making them more effective in mitigating the impacts of climate change.

UK Food Security and Ecosystem Risks

The Department for Environment, Food & Rural Affairs (Defra) work on safeguarding the UK's environment, agriculture, and food security is heavily supported by the climate research conducted under the Climate Programme. As the UK faces increasing risks from extreme weather events, such as floods and droughts, the need for accurate climate projections has never been greater. The Climate Programme provides these projections, enabling Defra to develop strategies that protect vital ecosystems and ensure the resilience of the UK's food supply.

One of the key contributions of the Climate Programme to Defra is through the Defra-funded Climate Services, which focus on the impacts of climate change on farming and the broader food system. These services inform policymakers about necessary adaptations, such as improving water management in agriculture or enhancing the resilience of food supply chains. By integrating our research into its policies, Defra can better prepare for the challenges that a changing climate presents to the UK's natural environment and food production systems.

Global climate negotiations

On the international stage, research and evidence carried out as part of the Climate Programme directly informs applied science and services funded by the Foreign, Commonwealth & Development Office (FCDO) & other Government Departments to support global action on adaptation and resilience particularly in, but not exclusively, in developing countries. Research supports the UK's contributions to global climate negotiations and international climate agreements, as well as contributing to the assessments of the Intergovernmental Panel on Climate Change (IPCC).

Met Office Hadley Centre scientists provided authorship and review support to IPCC Sixth Assessment Report – a crucial document used for informing global climate policies and the setting of targets for

emissions reductions.

Met Office contributions to the Intergovernmental Panel on Climate Change Sixth Assessment Reports (IPCC AR6) Working Group reports (WGI, WGII and WGIII)

Working Group I report - The Physical Science Basis, contains:
• 1,090 papers and book chapters cited a total of 3,900 times
• 18 datasets cited a total of 170 times
• 23 models and model variants cited a total of 194 times
Working Group II report - Impacts, Adaptation & Vulnerability, contains:
• 267 papers and book chapters cited a total of 1,039 times
• 3 datasets cited a total of 3 times
• 13 models and model variants cited a total of 261 times
Working Group III report - Mitigation of Climate Change, contains:
• 75 papers and book chapters cited a total of 312 times

More about our work with the IPCC

International climate resilience

Building on the Climate Programme's international leadership in climate science and its applications to policy and decision-making, FCDO Programming can undertake global engagement and positioning of the UK as a force for good working towards addressing the current global climate challenge helping build resilience. This aligns with the FCDO's diplomatic objectives and mission to support global development and growth whilst alleviating poverty, particularly in regions that are most vulnerable to the effects of climate change.

The ever-growing urgency to act ahead of high-impact weather and climate events to effectively build long-term climate resilience requires sustained commitments and partnerships worldwide, and needs-driven, action-focused research.

The UK has long-standing Programming focused on the adaptation and resilience agenda. As an example of active Programming that draws on the Climate Programme, the Weather and Climate Information Services Programme (WISER) focusses on increased quality, accessibility and use of information for action and resilience building in Africa, Asia-Pacific, and MENA regions. Another example is the CLimate Adaptation and Resilience programme (CLARE), the UK's £110m+ flagship research programme on climate adaptation and resilience, announced at COP26. CLARE is bridging critical gaps between science and action by championing Southern leadership of research. It supports partner governments, communities, and the private sector to use evidence and innovation to drive effective solutions to the climate challenge, whilst building capacity of both those carrying out the research and those using the resulting evidence. CLARE is mostly (about 90%) funded by FCDO, and co-funded and run by Canada's International Development Research Centre. You can read more about the work of this programme in our recent blog.

Due to the world-leading status of the Climate Programme, FCDO are able to reinforce the UK's position as a leading both mitigation and adaptation policy, diplomacy and climate action. The Climate Programme, in turn, benefits from the insights on how the evidence is used in decision making by the Government Departments involved to ensure that the UK remains a leader and relevant in international climate science.

Key Activities and Achievements 2021-2024

Each Climate Programme builds on the success of previous programmes, with research carried out in collaboration with leading research institutions and universities, both in the UK and internationally.

The 2021-24 Climate Programme was designed around four key questions posed by the UK Government:

1. ***Current weather and climate hazards, risks and impacts that should be expected in the UK and globally***
   Extreme weather events have severe impacts on society and ecosystems in our current climate, and pose an increasing threat as climate changes. Met Office Hadley Centre scientists have pioneered work in attribution science, which looks at whether climate change is responsible for extreme weather events, and to what extent.

   Multiple attribution studies were carried out during the 2021-24 MOHCCP, investigating some of the most impactful weather events in that period including an attribution study of the UK's record-breaking annual temperature in 2022, where human-induced climate change made this event around 160 times more likely.

   In December 2023, the Met Office annual global temperature forecast was published. Global average temperature rise is measured as the difference between 1850-1900: a proxy for the Industrial Revolution. It suggested that 2024 is very likely to be between 1.34°C and 1.58°C (with

a central estimate of 1.46°C) above the average for the pre-industrial period (1850-1900).

This was the first time that a year has been forecast with a substantial chance of exceeding 1.5°C above the average for the pre-industrial period. The Met Office's Dr Nick Dunstone, who led the forecast, stated that: "It's important to recognise that a temporary exceedance of 1.5 °C won't mean a breach of the Paris Agreement. But the first year above 1.5 °C would certainly be a milestone in climate history."

2. ***Future hazards, risks and impacts from weather and climate that we may wish to avoid or need to adapt to***
   Met Office scientists Neil Kaye and Deborah Hemming have been working in collaboration with biosecurity and forestry experts at Defra, Forest Research, Fera Science and the University of Warwick to provide scientifically robust and useful research, tools and guidance to help manage the climate-related risks to UK plants, particularly trees and forests, from plant pests and pathogens.

   The UK Climate-Pest Risk Web Tool integrates ecological knowledge and models of known temperature thresholds for different pests/pathogens, with up-to-date climate observation datasets from the Met Office National Climate Information Centre. It is used to estimate the timings and locations of pest outbreaks across the UK, and inform actions to support assessment and management of pest and pathogen risks to UK plants now and in the future. More about this tool can be found in our blog.

3. ***Carbon budget and mitigation scenarios will avoid the most dangerous impacts of global climate change***
   Prof Richard Betts, led a comment paper, published in Nature in December 2023, which discussed the need for a clear definition of current warming levels in the context of the Paris Climate Agreement to avoid confusion over whether a particular level of warming (e.g. 1.5°C) has been reached. This paper proposes a method to produce an indicator of current warming levels, which (incorporating observations and RCP4.5 projections) is around 1.25°C for 2022.

   To complement the newly proposed indicators, a new section was added to the Global Climate Dashboard to illustrate the current level of global warming. Led by Met Office Scientist Matt Palmer, the 'Indicators of Global Warming' dashboard displays eight separate indicators as well as observed global mean temperature using Met Office HadCRUT5 data, providing real time insights on the status of our efforts to keep warming below 1.5° C. You can here more about the dashboard in an episode of Climate Podcast.

4. ***The impacts and opportunities from mitigation and adaptation actions as we proceed towards a resilient and net zero future***
   At the UN's Climate Conference COP27, the University of Leeds, in partnership with the Met Office, launched an online tool, which help communicate the co-benefits of climate action.

   The Climate Co-Benefits Portal provides an assessment of the available scientific data on how climate interventions affect five impact categories; economy, ecosystems, energy, health and socio-cultural.

The portal assists in understanding the evidence on climate action co-benefits and trade-offs and can help identify where there is strong evidence to support policy development and decision making. The portal can be used to find out how climate mitigation and adaptation interventions influence other policy areas. More information was shared in our press release.

Future Directions and Challenges

Insights from our research is critical for planning and building climate-resilient infrastructure, essential for maintaining public safety and economic stability of key industries, such as agriculture, insurance, and energy, by providing the data needed to manage climate risks effectively. This not only protects jobs and livelihoods but also ensures that the UK can continue to thrive in a changing climate.

The Climate Programme continues its vital work through the 2024-2027 workplan, with a focus on addressing emerging climate risks and supporting the UK's net-zero transition. This is a crucial time for our planet as we try and slow global annual temperature increases as we get closer to the 1.5C Paris goal.

The new work plan was co-developed with UK Government and the Climate Programme's independent science review group. Science produced during this programme will underpin the climate research and data needs of the 4th Climate Change Risk Assessment and the UK contribution to the 7th IPCC assessment. Work has already begun supporting an IPCC special report on climate change and cities and the Coupled Model Intercomparison Project 7.

The Met Office Hadley Centre will continue to work with partners to deliver scientific knowledge, expertise and capacity to meet the needs of the UK Government and support the UK and global climate science communities to build a more resilient and sustainable future for all. And as the impacts of climate change become increasingly apparent, the importance of our climate research will only continue to grow.

Socially inclusive and sustainable action to build resilience to climate change

Description

This month, we have been looking more closely at the role of the Met Office Hadley Centre Climate Programme and how its research meets UK government evidence needs, supporting the UK and global climate community to understand and respond to climate challenges.

At a time when the response to the impacts of climate change have never been more pressing, there is an urgent need to embrace climate solutions and invest in resilience-building initiatives in order to push forward and navigate the challenges of a changing climate to create a more resilient, equitable, and prosperous world for generations to come.

Addressing these challenges requires us to focus on building strong partnerships within the wider climate science community to facilitate the sharing of expertise, skills, and capabilities across closely aligned research and development programmes.

The Met Office Hadley Centre is one of the World's foremost climate change research centres and our aim is to provide climate science and services to people and organisations, to allow them to make better decisions to stay safe and thrive.

The Met Office Hadley Centre Climate Programme

The Met Office Hadley Centre Climate Programme underpins climate-science research in the UK by delivering scientific knowledge, expertise, and capability (models, data and infrastructure) that meets the needs of the UK government and supports the UK and global climate community to understand and respond to climate challenges.

The Climate Programme provides information that is relevant to UK interests domestically and overseas, including providing data and learning from global observational datasets and global climate models. Where research includes aspects on large-scale drivers of climate variability and change this will, in many cases, be global in nature.

The programme will zoom in on the UK in more detail, and also other regions (such as Africa) where there is gearing from other projects or programmes (e.g. through CLARE). Additionally, the Met Office will ensure that techniques and analysis code developed for one focus region will be as transferable as possible to other locations.

CLimate Adaptation and REsilience (CLARE)

The UK-Canada framework research programme on Climate Adaptation and Resilience, known as CLARE is a key partnership designed, funded and run by the UK Foreign Commonwealth and Development Office and Canada's International Development Research Centre (IDRC) that is responding to the urgent need for climate solutions and resilience.

CLARE aims to enable socially inclusive and sustainable action to build resilience to climate change and natural hazards, with both organisations working closely to set the strategic and technical directions of the initiative.

Launched at COP26, The CLARE programme is primarily funded by the United Kingdom which provides nearly 90% of the £110m funding as part of FCDO Research and UK International Climate Finance. CLARE works to support partner governments, communities, and the private sector to use evidence and innovation to drive effective solutions to the climate challenge, whilst building capacity of both those carrying out the research and those using the resulting evidence. CLARE enables long-term, sustainable, and equitable economic and social development in a changing climate, whilst supporting early action to reduce the impacts of climate variability and providing a better understanding of the associated climate risks.

CLARE includes three core pillars:

1. Research, commissioning new substantive action-oriented research as well as providing the cross-programme infrastructure, jointly run and co-funded by the UK and by Canada's International Development Research Centre;

2. Services, providing timely weather and climate services to inform investments and actions by FCDO, UK government and wider stakeholders in partnership with the UK Met Office and others;

3. Partnerships, supporting strategic alliances on climate science and adaptation such as the Adaptation Research Alliance (ARA) and Climate Risks and Early Warning Systems (CREWS).

Since COP26, CLARE has become one of the most prominent research programmes in Climate Adaptation and Resilience globally. So far, 24 research projects are underway involving 136 organisations in 38 countries, three quarters of which in Africa and Asia. CLARE is developing research benefiting 30 countries by involving a wide range of organisations, from research institutions in a range of disciplines, to NGOs, local government, Meteorological Agencies and the private sector.

Grassroots Action Research Micro-grants through CLARE covered small projects in 23 countries enabling gender equitable and socially inclusive climate adaptation. These include a project in Ethiopia increasing women's resilience to climate change through climate smart agriculture tools and enhancing food security through fruit production. And, in Ghana, an inventory of solutions to address the twin challenge of climate change and urban environmental problems in Sub-Saharan Africa, aiming to increase the involvement of young people into climate action in the region.

As a partner, the UK Met Office is playing a key role in a number of CLARE research projects and this blog will explore and explain the key aims within the projects of:

- A Pan-African and Transdisciplinary Lens in the Margins: Tackling the Risks of Extreme Events (PALM-TREEs)

- Resilience and Preparedness to tropical cyclones across Southern Africa (REPRESA)
- Methods to Enhance Capability in High-resolution information for Adaptation: Initial Case Studies (MECHANICS)
- Seasonal IMpact-Based OutLooks (SIMBOL)

PALM-TREEs

A Pan-African and Transdisciplinary Lens in the Margins: Tackling the Risks of Extreme Events (PALM-TREEs) is a three-and-a-half-year project of the CLARE programme, which brings social and physical scientists together with stakeholders to challenge the conventional understanding of extreme climate events.

PALM-TREEs will seek to improve the understanding of the socio-economic impacts of extreme climatic events by highlighting how inequalities lead to discrepancy in climate risk among marginalised communities and how adaptation can help support these communities in a changing climate. The project aims to equip marginalised communities in South Africa, Cameroon, Ghana, Kenya, Nigeria, and DR Congo, with the necessary tools to better respond to droughts, floods, and heat waves.

The project involves a consortium of universities and institutions led by the University of Cape Town, the University of Yaoundé 1 and the University of Oxford. As a project partner, our primary role is to provide support, training and mentorship to the activities being carried out by early career researchers and collaborate on research projects.

Through a co-production approach, researchers work closely with stakeholders to develop new approaches to make this climate information more usable and accessible. The project will also focus on strengthening the inclusive and equitable knowledge networks needed to support climate resilience.

REPRESA

Resilience and Preparedness to tropical cyclones across Southern Africa (REPRESA) is a CLARE project focussing on the impacts of landfalling Tropical Cyclones (TCs) in Madagascar, Malawi, and Mozambique.

The impacts of TCs are devastating; in March 2019, over one thousand people died following the worst flood disaster in the region's history caused by the landfall of TC Idai, and more recently, in February-March 2023, hundreds lost their lives when Cyclone Freddy hit the region, a TC with unprecedented persistence.

Despite their severe impacts, little is known of the changing attributes of TCs affecting the region in a warmer world. REPRESA aims to provide this necessary understanding of compound TC flood risks and the likelihood of unprecedented impacts, through state-of-art climate and flood modelling. It will pull-through scientific advances to achieve improved resilience through in-country leadership, training, and community engagement.

REPRESA brings together an interdisciplinary team of world-leading and physical scientists and is co-led by three organizations: the Global Change Institute of the University of the Witwatersrand (GCI) in South Africa, the Eduardo Mondlane University in Mozambique (UEM), and the University of Bristol in the UK. It includes partners across southern Africa, Europe and the UK.

Outcomes of the REPRESA project include improved early-warning uptake, strengthened anticipatory action plans and better-informed climate adaptation planning, in the context of intersecting vulnerabilities. The Met Office is playing a key role throughout the project, including contributing new very high resolution (km-scale grid spacing) climate simulations for Africa that are better able to capture the intense rainfall associated with TCs. The Met Office is also the focal point for capacity

strengthening, working with the national hydrometeorological services to increase capacity in impact-based forecasting.

MECHANICS

The twenty-month long CLARE project; Methods to Enhance Capability in High-resolution information for Adaptation: Initial Case Studies (MECHANICS) project has just commenced and is being co-led by a team of researchers from Zambia, South Africa and the UK. It's overall aim is to build capability and develop case-studies in applying high resolution (km-scale) climate information for adaptation. Recent work on convective-scale (<4km) modelling over Africa has demonstrated its value in improving representation of the climate including extreme events.

MECHANICS will develop two decision-led "Km-scale Application Case Studies", the first in Lusaka and the second in South Africa and will demonstrate how Km-scale information can aid real-world evaluation of adaptation options by decision makers. Both will develop an understanding of decision-contexts of the impacted systems and incorporate into these more robust findings on relevant changes in the climate and their impacts generated from integrating new high resolution climate information with the current understanding of these changes. The project will also build capability to undertake, and act as a demonstrator for, the use of high-resolution climate data to improve the robustness of context-relevant climate information and so enable better climate adaptation and resilience decision-making.

The first case study, led by the University of Zambia and Climate Systems Analysis Group at the University of Cape Town, will focus on supporting the city of Lusaka, Zambia, to adapt to increased perennial flooding. The second case study will be led by the Global Change Institute of the University of the Witwatersrand and the Agricultural Research Council and focuses on supporting farmers and city planners in South Africa adapt to reduced spring rainfall and later onset of the rainy season.

The Met Office Hadley Centre will support these southern African research teams and will lead work generating evidence for how Km-scale modelling can enhance the robustness of climate information for adaption decision-making, to guide future investment in the underpinning science, technical

infrastructure and human capacity.

SIMBOL

Communities across the world are sensitive to the impacts associated with seasonal climate variability, particularly in regions reliant on rainfall seasons that support economic activities. Despite advances in seasonal forecasting over the past two decades, there has been limited progress in the generation and use of *impact-based* seasonal outlooks, that more directly serve societal needs while preserving the inherent probabilistic nature of the information.

The Seasonal IMpact-Based OutLook (SIMBOL) project, funded through the CLARE programme from October 2023 to March 2024, has advanced a new method to address this gap within Regional and National Climate Outlook Forums. The project was delivered by the Met Office and University of Bristol, supported through the Met Office Academic Partnership (MOAP), and in collaboration with the Intergovernmental Authority on Development (IGAD) Climate Prediction & Applications Centre (ICPAC) – the regional climate centre for East Africa.

SIMBOL has developed a simple-to-use and standardised methodology that can be adopted across the world, building on Impact-Based Forecasting (IBF) for early action on weather prediction timescales. Utilising co-production sessions, impacts specialists and stakeholders integrate different sources of evidence to jointly characterise impacts (for selected hazards, regions and sectors) for each forecast category irrespective of the forecast probability, and then integrate with seasonal forecasts to determine levels of risk and issues advisories.

A case study has been developed, focused on the impacts of seasonal total rainfall on groundwater availability in Somalia, and trialled at the 66th Greater Horn of Africa Climate Outlook Forum (GHACOF-66) in Uganda in February 2024. Feedback from the trial was very positive and work is now advancing towards implementation of the approach through other programmes, including the FCDO funded Weather and Climate Information Services (WISER) programme.

Research supported by CLARE is bridging critical gaps between science and action by championing Southern leadership of research. Through CLARE, the programme is developing new tools and supporting partner governments, communities, and the private sector to use evidence and innovation to drive effective solutions to the climate challenge, whilst building capacity of both those carrying out the research and those using the resulting evidence. This work supports locally-led, socially inclusive and sustainable adaptation action through building true and equitable partnerships.

New portal improves air quality data accessibility

Description

A new portal is providing free, public access to nearly two decades of air quality data across the UK.

The Met Office Air Quality Data Portal is now live, making national data from January 2003 until December 2019 available in one place for the first time.

It gives users access to aggregated data and other resources, so they can get detailed insight and greater understanding into air pollution levels in England, Scotland, Wales and Northern Ireland.

The platform uses geospatial technology from Esri UK, and hosts Met Office data from its UK Air Quality Reanalysis dataset, generated as part of the Clean Air Programme.

Paul Agnew, Scientific Manager – Air Quality Modelling at the Met Office, said: “Our Air Quality Data Portal offers a detailed insight into UK surface air pollution, and how it varies by location and over time.

“The portal demonstrates our commitment to making atmospheric data publicly available. We hope it will give users a better understanding of air pollution and its impacts, so they can help improve air quality for a heathier future.”

The portal has been created for a variety of users, including academic researchers (atmospheric science and pollution health impacts), central and local government officers, air quality professionals and the public.

Users can visualise and analyse the portal data in map and timeseries format, or download it in a variety of formats to use offline and share with others.

They can search and extract data on different pollutants for specific locations across the UK and time periods, enabling them to obtain statistics and calculate averages.

For example, a science teacher could find out how average levels of sulphur dioxide, produced from the combustion of coal or crude oil, have changed in the UK since 2003. Or a researcher, who is looking into the health impacts of particulate matter from road transport, could establish which areas of the UK have the highest emissions.

Story Maps are available to give users in-depth information about topics including: sources and emissions of UK air pollution, differences between urban and rural air quality, and notable past episodes of poor air quality.

There is also an introduction to air pollution in the UK, including information on key pollutants, and how air pollution is forecast and measured.

Using data from the Met Office Air Quality Reanalysis, the portal provides monthly and yearly averages of surface pollution levels at locations throughout the UK. This is based on hourly measurements from 1 January 2003 up to and including 31 December 2019.

The Met Office is involved in air quality research projects, both at local scales over days to weeks, and at the global scale for periods of decades up to 100 years into the future. It provides five-day national air quality forecasts for the public, as well as advice for those more susceptible to high levels of air pollution.

The Clean Air programme is led by the Met Office and the Natural Environment Research Council (NERC). It supports high quality multi-and inter-disciplinary research and innovation to develop practical solutions to air quality issues in the UK.

Navigating My First Weeks at the Met Office and Championing Climate Science

Description

In this blog, Professor Rowan Sutton writes about his first month here at the Met Office as he takes up the role of Director of the Met Office Hadley Centre.

I am writing this blog at the end of my fourth week working at the Met Office. I was asked by my colleague, Oak Wells, whether I felt like I was being continually sprayed with a fire hydrant – and this isn't a bad simile. There has certainly been a lot to assimilate, and this will clearly be the case for some time yet. But it has been very enjoyable. Colleagues, new and old, have been very welcoming, and it's been great to hear about all the fascinating work going on in all corners of the Met Office. And there are a lot of corners!

A passion for climate science

I have spent most of my career in the academic world, much of it based at the University of Reading, working within and for NERC's National Centre for Atmospheric Science (NCAS). I have a passion for climate science and its critical role in helping society address the urgent challenges of climate change. My personal research has focused especially on the role of the oceans in climate variability and change, predictability and prediction.

At Reading, I initially held a research fellowship and later became Director of Climate Science for

NCAS. I have been involved in a wide range of international activities including serving as a Lead Author of the IPCC Fifth Assessment Report, and recently as Co-Chair of the World Climate Research Programme Lighthouse Activity on Explaining and Predicting Earth System Change. Two years ago, I took on a new part-time role as Research Dean for Environment, working with Tom Oliver, an ecologist. We worked together to develop and promote Reading's diverse portfolio of research relevant to sustainability – driving the message that meeting the challenges of sustainability needs *everyone*.

Throughout my career, I have collaborated with Met Office colleagues and more recently, I have come to learn more about the work of the Met Office Hadley Centre through my role as Chair for the Science Review Group.

I led an international academic panel to independently review climate research, underpinned by the Met Office Hadley Centre Climate Programme, and advise government stakeholders on the quality, robustness and relevance of these science outputs.

A champion for climate science

And now I have the honour and responsibility to serve as Director of the Met Office Hadley Centre. What will be my approach to this role? In broad terms, *our ambition must be for the Met Office Hadley Centre to continue to be recognised as an international leader in climate science and its applications to policy and decision-making*. Advancing climate science is essential because there remain fundamental gaps in our knowledge about how climate is changing and how it will change in the future, and these gaps are key obstacles to effective adaptation and mitigation. Without climate science we are driving planet Earth into the fog. So, my first goal is to be a champion for climate science.

In addition, we must focus our efforts in those areas where the Met Office has unique strengths. These strengths relate especially to our capabilities for monitoring and modelling climate and Earth System change. We must continue to push the frontiers of these capabilities, so that they remain world leading. I am also particularly interested in the opportunities to better combine observations and models to advance the science and inform decision making.

In a fast-changing world we must be rapidly responsive to new opportunities. Of course, Artificial Intelligence and Machine Learning stands out as a key area of opportunity at this time, and it's been great to hear of the exciting work in this field already underway at the Met Office.

Partnerships are vital. The urgent challenges of climate science and climate change are far too large for any one organisation, so ensuring that we have the right partnerships in place, and are making the most of these, must also be a high priority for us all.

I still have a lot to learn about the work of the Hadley Centre and the wider Met Office, about changing customer needs and seeking and making the most of many new opportunities. All whilst I attempt to manage the continued spray from that fire hydrant.

Collaborating for energy network resilience

Description

The UK Government’s plans to transition to clean energy are crucial to achieving Net Zero targets and are built on a foundation of renewable generation. Just as delivering clean energy is far more complex and wide reaching than just wind and solar capability, so too, is the Met Office’s role in supporting the energy sector.

Evolving energy forecasting

Energy forecasting has already evolved with the transition from fossil fuels to renewables. It is now poised to be revolutionised with the move to ensemble data, enabled in part by the investment in the Met Office new supercomputer. Using ensemble data will provide more accurate and detailed weather forecast data for the new energy forecast model being developed by the electricity system operator (ESO). The Met Office is also collaborating with the ESO to identify the necessary data needed to support a range of energy modelling for sub-seasonal to climate timescales. This effort is specifically focused on understanding the energy needs for the 2030’s and beyond. Working with Ofgem, the Department for Energy Security and Net Zero (DESNZ), the Climate Change Committee (CCC) and ESO, the Met Office aims to make data sets and guidance available for use by the entire energy sector. This initiative seeks to provide consistency, reduce duplication, and lower costs across various projects and research efforts exploring future energy models and needs.

Enhancing network resilience

Forecasting energy supply and demand, and understanding the energy future, is only part of the picture. While generating and storing energy is crucial, it is ineffective without the infrastructure to transmit and distribute it to users. Weather and climate can impact all aspects of this infrastructure making it vital to understand related standards to enhance network resilience and potentially reduce build and upgrade costs.

The Met Office has closely collaborated with SSE-Transmission on several projects, including Ice Accretion and Corrosion maps, to improve design and build while reducing costs and maintaining safety. The impact of weather extends beyond design and build to the efficiency of the network. Work on static and dynamic line rating has the potential to improve infrastructure efficiency, reducing costs and expediting the connection to the new clean energy sources. Other projects are ongoing across the energy sector not least with National Grid Transmission and EDF Nuclear.

The Met Office continues to develop its partnerships with DESNZ, Ofgem, ESO, and other key industry stakeholders including those in the nuclear sector. The scope of the current activities is extensive and expanding. With the announcement of Great British Energy, we are poised to support another pivotal partner in the energy landscape.

The unbelievable May that had everyone talking

Description

“I’m not sure anyone believes you, it was a very cold month”, “My heating was on all month”. Just two examples of the replies to our statistics release that May 2024 was the warmest on record for UK mean temperature in a series dating back to 1884.

In a month that was wet and dull for many, people certainly didn’t feel that May was a record breaking month. But what could cause such a disconnect between perception and statistical reality?

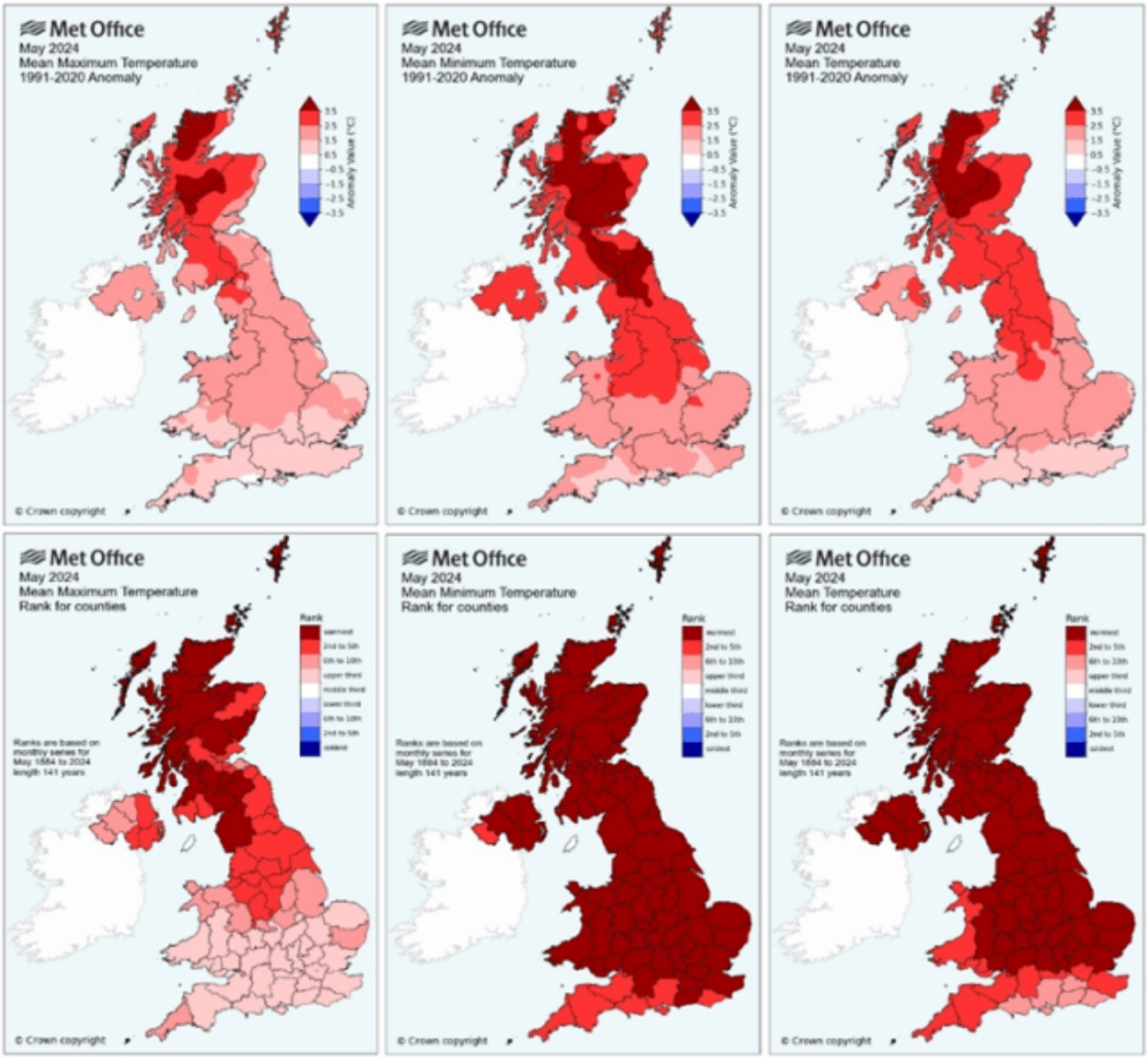
New analysis

In new analysis, Met Office scientists have looked at what caused such anomalously high temperatures for May, and the results go some way in explaining why people’s perceptions may not align.

At first sight it was obvious that unusually high temperatures across Scotland and northern England had played a significant role in the overall monthly temperature figures. It was also clear that the mean minimum, or average overnight, temperatures were notably high and had influenced the mean monthly temperature as a whole. A large component of the higher than average temperatures were also in less densely populated parts of the UK.

The maps below illustrate this and show that the anomalies were high enough even down to southern England to set new records. The top row shows the temperature anomaly, the second row are May records by county, the dark red colour represents a record.

But what was driving these anomalous temperatures?



These maps clearly illustrate the extent and the magnitude of the anomalously high temperatures through May. Even though the highest anomalies were further north, records were broken all the way down to the south of England for mean and mean minimum temperature.

Using a new technique developed by Met Office scientists in response to the record-breaking UK mean air temperature and marine temperatures in June 2023, the team were able to examine the influence of a marine heatwave that was surrounding the UK through Spring and into June 2024.

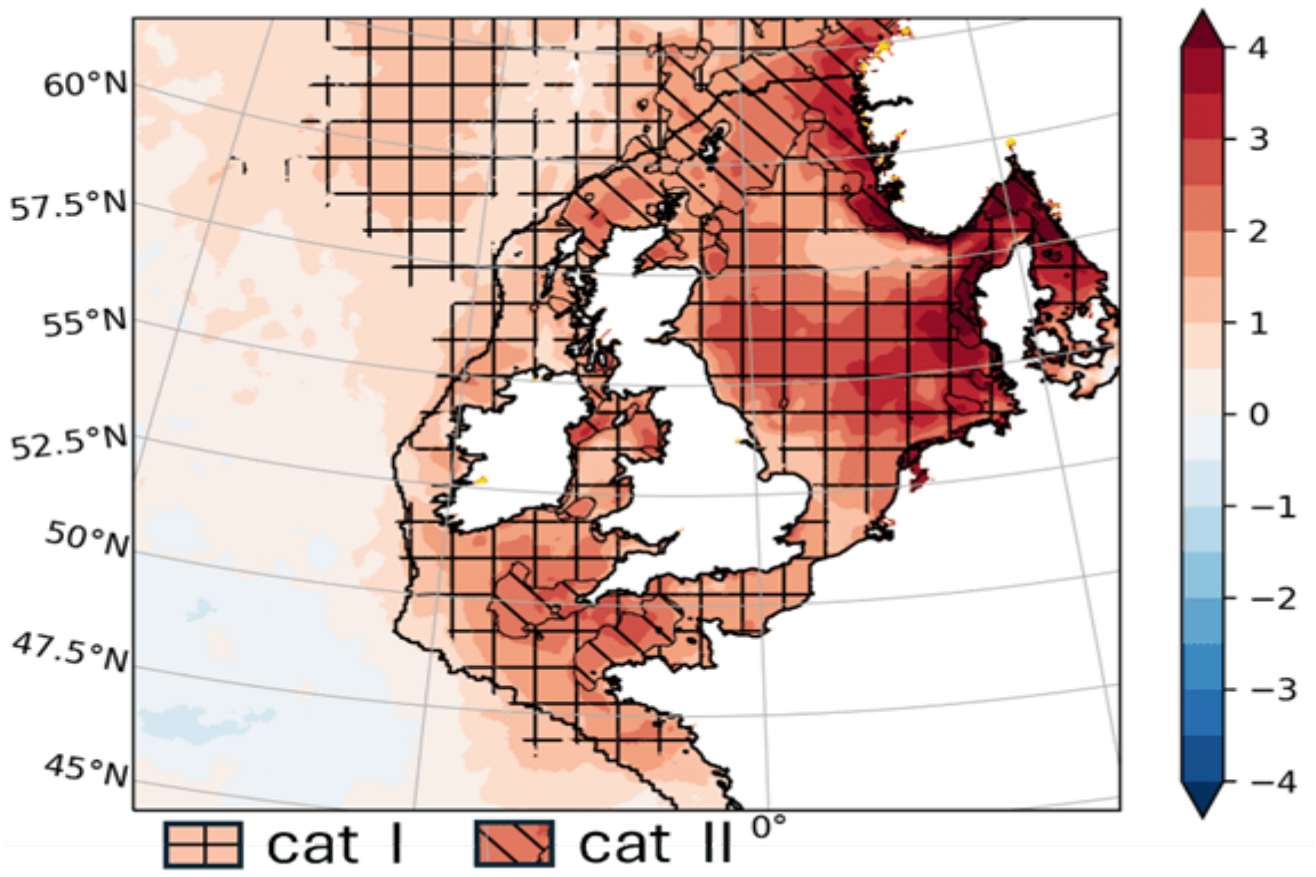
What is a marine heatwave?

Marine heatwaves are defined as periods of at least 5-days exceeding the 90th percentile of sea surface temperature (SST), calculated from the first 30-years of the satellite observation period (1982-2012). They are then categorised on a scale of I (moderate) to IV (extreme) based on deviation from local climatology.

For the waters around the UK in May, the marine heatwave threshold is 11.3°C. The SSTs around the UK were nearly 1°C above this threshold in May 2024.

The SSTs in 2024 started warm, with an anomaly close to a category I marine heatwave, this warm anomaly persisted until the start of May, when it amplified and reached marine heatwave status. This marine heatwave lasted for the whole month of May and the first week of June. It peaked to category II on the week of 18th-24th May.

The map below shows its spatial extent for that week, showing it was affecting the whole of the shallow seas surrounding the UK, known as the Northwest European shelf (NWS), and reached category II in the Northern North Sea and the Celtic Sea, with +2.5-3.5°C locally.



Sea surface temperature anomaly for 18 – 25 May from 1982-2012 climatology. Squared hatches: marine heatwave category I, backslashes: marine heatwaves category II. 18-25 May is peak week of MHW. The Northwest European shelf is also marked with a black line.

Influence of marine heat on land temperature

By using the new method developed by the Met Office's Dr Ségolène Berthou, the team have been able to show that the May marine heatwave over the Northwest European shelf warmed the UK land temperature by +0.5°C (relative to the 1983-2012 baseline) on average over the month of May.

Dr Berthou explains: "Although May was a fairly cloudy month over the UK, the marine heatwave was found to coincide with generally clear skies and weak wind and wave conditions over the North Sea, which we know drive marine heatwaves.

"These conditions coincided with a weak northeasterly airflow, which allowed the North Sea temperatures to influence UK land. By using our peer reviewed method, we can calculate this influence to be +0.5°C averaged over the whole month."

In our latest episode of Climate Conversations, Clare Nasir speaks with Dr Ségolène Berthou who led on the new marine heatwave methodology. Watch the video below to learn about the initial study and how they can calculate the influence of marine heatwaves on UK land temperature.

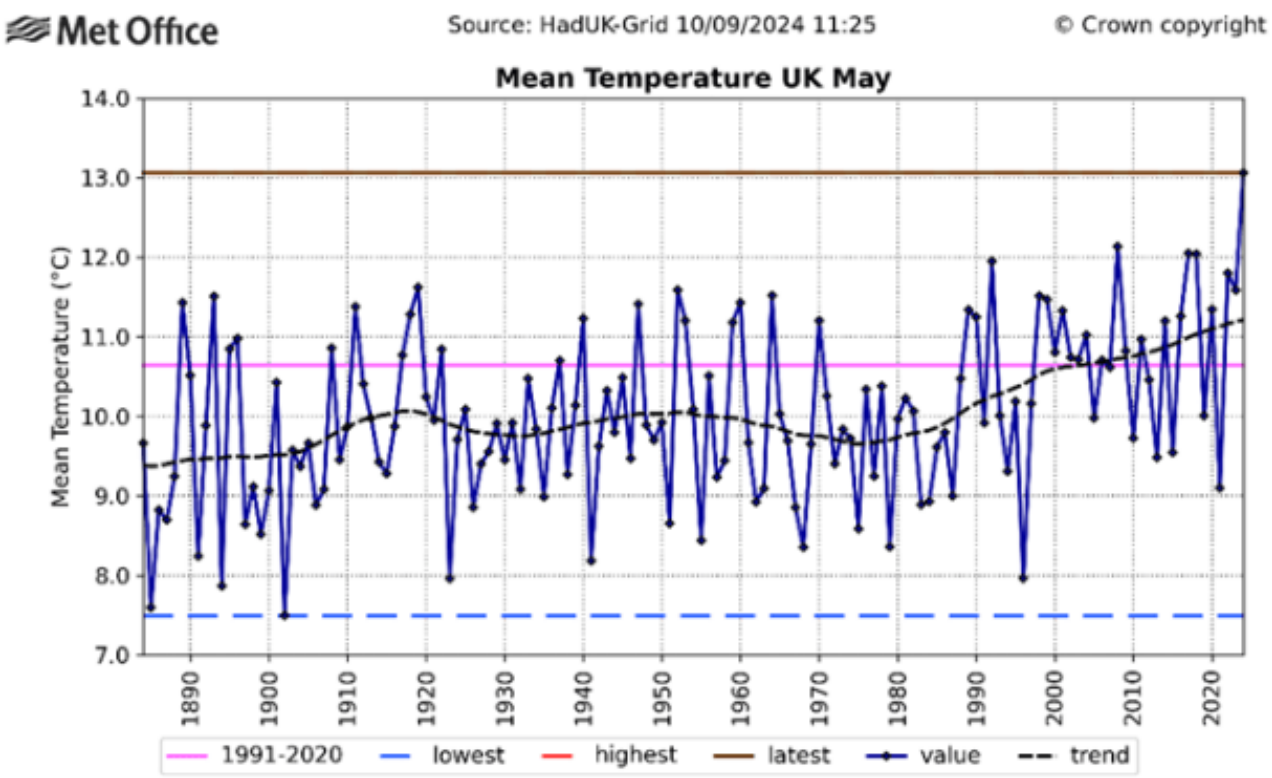
The May 2024 marine heatwave contributed significantly to the land record anomaly. To put it into context, the UK mean temperatures in May broke the previous record by around +1°C. The east coasts of Scotland and England were the most impacted by the marine heatwave where land temperature was increased by 0.8-1.0°C. This is likely because of their location close to the North Sea where the largest SST anomaly is located, and because of the weak northeasterly airflow that dominated in May.

While the UK's population experienced a cloudy and, in places, wet May, the brighter conditions over the North Sea and northeasterly flow influenced our temperatures, and cloud-cover over land prevented overnight cooling. This goes some way in explaining the disconnect between perception and statistical reality of May 2024. The North Atlantic was also experiencing its warmest May ever recorded at the surface, and it is possible is also contributed to UK temperatures.

Influence of climate change

Sea surface temperatures over the NWS have been increasing by around 0.3°C per decade over the last 40 years and this is leading to more frequent marine heatwaves around the UK.

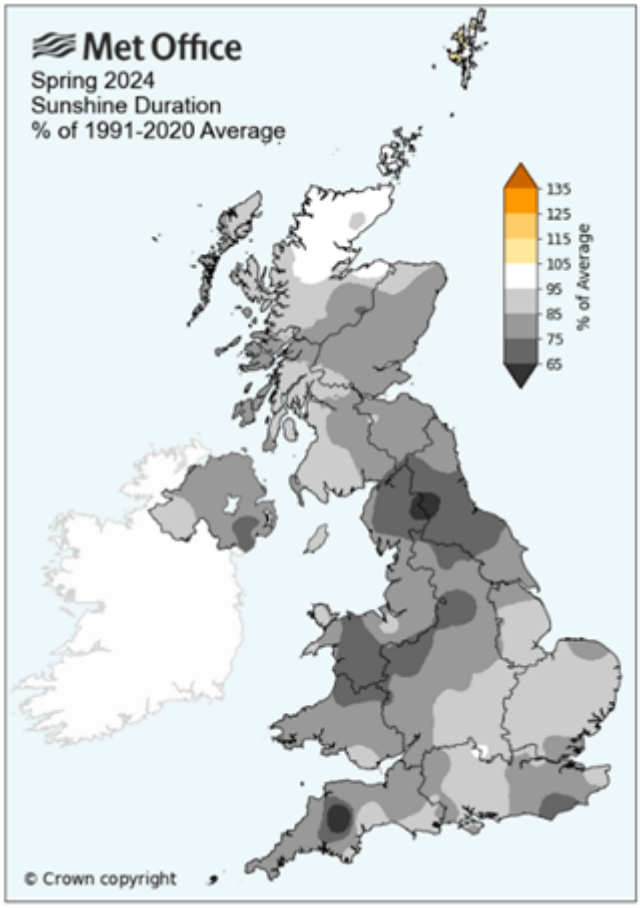
Looking at UK land air temperature for May, as with the annual and seasonal series there is large variability. However, there is a marked increase in May mean temperature from the 1980s onward as shown in the graph below. The May UK mean temperature has increased from 9.76°C in the 1961-1990 averaging period to 10.65°C in the 1991-2020 averaging period. The annual State of the UK Climate goes into much more depth on the influence of climate change on the UK's months, seasons and years across all meteorological variables.



Graph showing the mean UK temperature for May back to 1884.

Perception vs reality

As we all know, it feels much warmer when you're in direct sunlight. It is the reason we measure air temperature from inside Stephenson screens, to protect the thermometer from the suns direct warmth. With this in mind, the Spring sunshine statistics also help explain people's perception of the May temperature. As the map below shows, most of the UK had a dull three months through spring, which will have also influenced the feeling of warmth in this transition season when the sun is gaining strength.



May sunshine duration map for the UK.

When combined, the significant influence of a marine heatwave, lack of sunshine through Spring, and the background warming of the atmosphere driven by human induced climate change help explain why record breaking mean temperatures can occur even when people don’t perceive it to have been a particularly warm and sunny month.

A cool career studying the impacts of a warming planet

Description

In this blog Professor Peter Stott MBE writes about his recent interview on the BBC programme 'The Life Scientific' and reflects on his career.

I've been listening to *The Life Scientific* on Radio 4 for years. Hosted by physicist Jim Al-Khalili, I've enjoyed learning about the lives of scientists from all sorts of disciplines and discovering new things about their research. It's been fascinating hearing from colleagues who've themselves been guests, including our former Chief Scientist, Julia Slingo, Myles Allen from Oxford University who I've collaborated with over many years, and Tim Lamont, The Life Scientific's youngest guest who was part of the *Climate Stories* communication project I ran with my wife, Pierrette Thomet, in 2018.

I've got to know Jim's regular introduction, almost by heart: "This is the show where I get to talk to some of the world's leading scientists and you get to find out what drives them".

Professor Peter Stott MBE, Climate Science Fellow.

A surprise invitation

So, imagine my surprise and delight (even if a little apprehensively tinged), when I received an email from programme producer, Lucy Taylor, asking if I wanted to take part as a guest. It didn't take me long

to say yes, and a few months later, on 28 August, I was being interviewed at BBC Broadcasting House.

I had sent her some of my most important published papers along with a copy of my book *Hot Air: The Inside Story of the Battle Against Climate Change Denia*l which tracks the personal challenges I've faced working on this crucial area of science. This informed a very detailed online discussion with Lucy about my career a week before the recording. From this Lucy devised a running order with Jim (which I got to see in advance), and a set of questions for Jim to ask me (which I did not get to see ahead of time!).

Professor Peter Stott MBE at the Royal Society Book Prize event in 2022 with Jim Al-Khalili.

An opportunity to reflect

Appearing on the show gave me an opportunity to look back on my life, starting with my days growing up in Southport, where my passion for hiking in the mountains, and my interest in the weather, began. I was also asked about the various staging posts along the way before I arrived at the Met Office Hadley Centre in 1996 including modelling the fallout from Chernobyl for my PhD. I was keen to tell Jim about the unforgettable moment in March 1996 when I first met John Mitchell, then the organisation's chief climate modeller, at the Met Office college in Reading.

I reached the second interview at the Met Office, where candidates were paired off with prospective managers. John needed somebody to work with Simon Tett (now at Edinburgh University) on a new challenge, to detect the fingerprints of anthropogenic climate change. He showed me a plot of

observed changes in temperature over the globe as well as those from his latest model simulation. The two patterns didn't seem that alike to me although I could see that they both showed warming overall. But the puzzle John wanted to solve – whether these two patterns agreed more than you would expect by chance – did seem utterly fascinating. I realised that, finally, I might have found my scientific niche in detection and attribution of climate change.

I couldn't believe my luck when John offered me the job, and I haven't believed my luck many times since during a 28 year career (and counting) in the Met Office when I've been given some amazing opportunities to do some really cool stuff. Despite the depressing nature of environmental degradation and the often slow progress internationally in tackling the problem, it is very rewarding to have been engaged in scientific work that has helped alert people and governments to the issue and has supported societies in becoming more resilient to extreme weather. I remain hopeful that in the next few years our fingerprinting techniques will detect the slowing of climate change as a result of actions to reduce emissions.

- Listen to Peter Stott on The Life Scientific on Radio 4
- New Years Honours

About Peter

Peter has been a significant contributor to the progression of Climate Science nationally and globally, being the first to link an individual weather event to climate change (the 2003 European heatwave). He is seen as a pioneer in establishing the scientific case for action on climate change, with his crucial attribution work providing evidence and advice to Governments and the public, supporting policy making and decisions.

Peter has played a major role in the Intergovernmental Panel on Climate Change (IPCC) and a leading public role in rebutting climate denial and defending the integrity of climate science. Peter's book countering the narrative of climate denial, was recently shortlisted for the Royal Society of Literature's Christopher Bland Prize and for the 2022 Royal Society Science Book Prize. He is passionate and creative about climate science communications, working extensively in the media as well as being a mentor to encourage young scientists in their climate communications.

Ten years of forecasting beyond the skies

Description

The Met Office Space Weather Operations Centre (MOSWOC) celebrates ten years of operations this week, looking back on a decade of forecasting potential impacts from the Sun.

Since becoming fully operational in 2014, MOSWOC has forecasted and monitored thousands of space weather events, helping key industries take steps to manage the risks posed by our dynamic Sun.

One of just a handful of 24/7 space weather forecasting centres in the world, MOSWOC is constantly monitoring the Sun for space weather activity, including solar flares, solar radiation storms, and coronal mass ejections which lead to geomagnetic storms here on Earth.

Met Office Chief Executive Penny Endersby, Met Office Head of Space Weather Mark Gibbs and Parliamentary Secretary at the Cabinet Office Abena Oppong-Asare MP.

Since its creation, MOSWOC has issued over 1000 warnings for space weather, helping to provide satellite operators and other critical infrastructure providers with advanced notice so they can consider necessary actions to minimise any impacts on the public.

A new independent report released this week suggests that the Met Office's space weather capability will be worth over £600million to the UK over the next decade.

In addition to operational forecasting, MOSWOC plays an active role in the international scientific community for the advancement of space weather sciences, helping to develop global monitoring and forecasting capability and advance scientific understanding.

Met Office Space Weather Manager Simon Machin said: "We're proud to have been at the forefront of space weather forecasting over the last ten years.

"While many people will know about space weather from being responsible for the beautiful auroral displays we sometimes see, our forecasts have helped satellite operators and key infrastructure to mitigate impacts from severe space weather events and will continue to do so in the future.

"The next decade will encapsulate huge leaps forward for global space weather forecasting, with a number of projects set to enhance international capability, including the launch of the European Space Agency Vigil mission, which will provide a side-on view of the Sun to enhance forecast accuracy."

Find out more about space weather forecasting at the Met Office.

On the path to delivering next generation UK weather forecasts

Description

Reporting on progress of the Met Office and Alan Turing Institute AI for Numerical Weather Prediction project.

The UK’s weather is notoriously changeable, prompting everything from casual conversation amongst friends to vital decision-making by Government and industry that affects our lives and livelihoods.

Behind the scenes, there is a paradigm shift underway in how we’ll get our daily dose of meteorological information. Artificial intelligence (AI), and more precisely machine learning (ML), is making significant strides in weather prediction, and the UK is at the forefront of this exciting development.

A powerful partnership

A key factor in this progress is the collaboration between the Met Office and the Alan Turing Institute which is helping maintain the UK’s position at the cutting-edge of weather prediction and deploying AI for public good.

The benefits are mutual. Met Office experts have been able to provide crucial training in meteorology and the metrics used to evaluate weather models, while researchers from the Turing have shared their expertise in AI model design and optimisations for scaling-up on cloud platforms.

This partnership has galvanised a new cross-disciplinary team and the exchange of knowledge and skills is accelerating innovation and driving forward the field of weather prediction.

Progress report

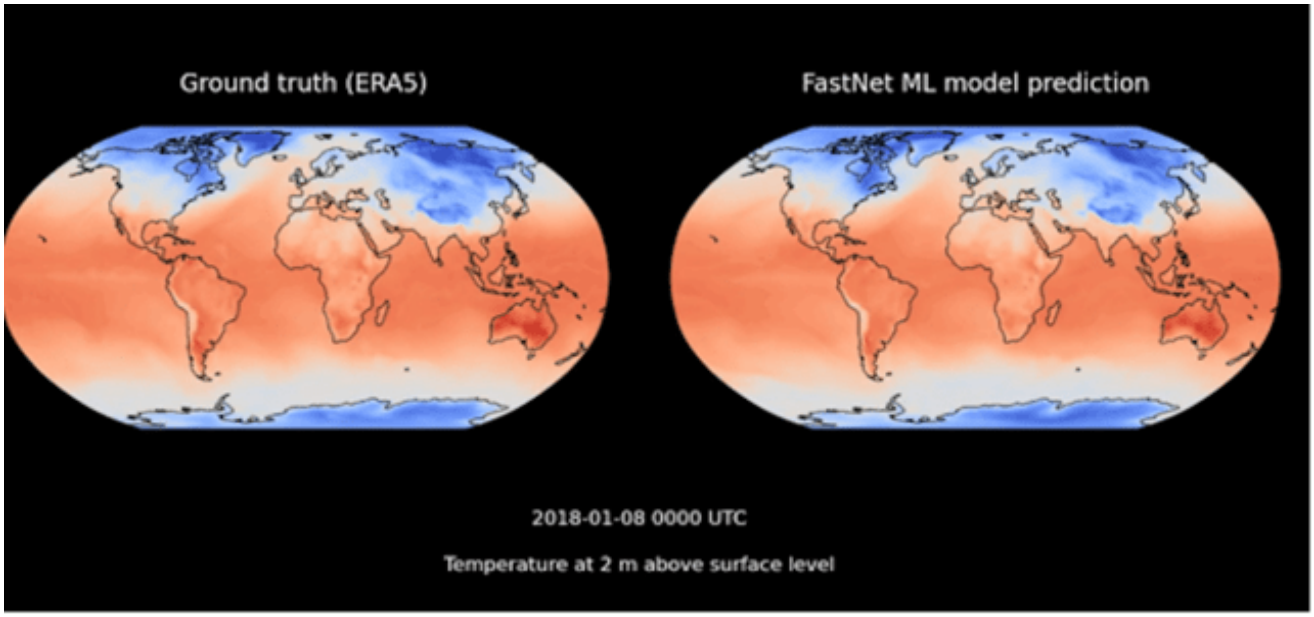
So, what have we achieved so far? It's early days but the results are already promising.

We have developed a machine learning model for weather prediction: "FastNet", showcasing the potential of this technology to visualise complex weather patterns on a planetary scale.

FastNet, and other AI models like it, represent the next step in the evolution of weather prediction, showing the UK's commitment to embrace new technologies to remain at the cutting-edge of weather forecasting.

We're really pleased to see that for some metrics the FastNet model's performance is comparable to that of the Met Office's Global Numerical Weather Prediction (NWP) system, an international gold standard in weather forecasting

This is a significant milestone, demonstrating that AI is not just a theoretical concept but a practical tool with the potential to match and even exceed the capabilities of traditional methods. Drawing together AI and traditional physics-based models for weather prediction offers the chance to magnify the strengths of both approaches with models that are fast, accurate, explainable and trustworthy.



A frame from an animation comparing ERA5 (a reanalysis which uses a blend of observations and numerical weather prediction model to produce the best estimate of historical reality) with a prediction from the FastNet machine learning model.

Behind the scenes, a large-scale effort is underway to build a robust data infrastructure that can seamlessly integrate multiple data sources into the AI model. This may not be the most glamorous aspect of the project, but it's a critical step laying the foundations for continued sustainable development and ensuring that the AI model has access to the most comprehensive and up-to-date

information possible.

The word FastNet will be familiar to many as one of the 31 sea areas covered by the Shipping Forecast: a nod to the Met Office's founder, Vice-Admiral Robert FitzRoy, the first professional weather forecaster, who established the Shipping Forecast.

The future of UK weather forecasting

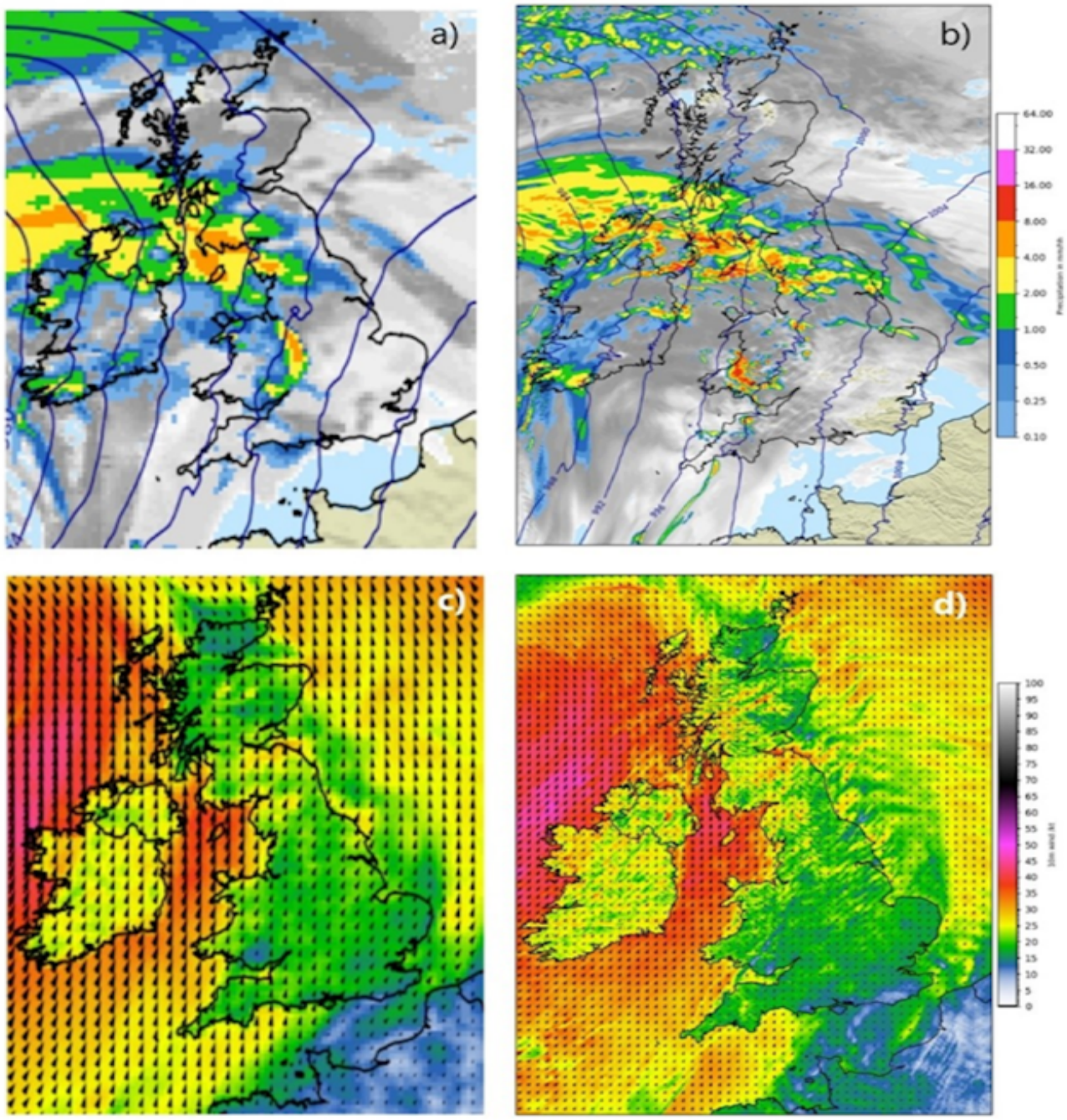
The ultimate goal of this collaboration is to operationalise the FastNet model so that the Met Office can use the optimal blend of physics-based and ML-based modelling for UK weather prediction. This means that AI could be used alongside physics-based models and play an important role in delivering the daily forecasts that we all rely on. We believe that using AI alongside physics-based numerical models provides the most robust way forward in a changing climate.

The next few months should deliver some important advances in FastNet. Building on initial success with FastNet in global predictions, the partnership will next develop high-resolution regional forecasts for the UK using AI methods.

By ingesting past UK weather forecasts into the FastNet training process, we will further train and refine it to produce detailed regional UK weather forecasts for potential operational use.

For example, this will include:

- **The use of multi-resolution input data** Traditional weather and climate models often operate close to the limits of the available computational resources, pushing supercomputers to the max, and so compromises need to be made: either reducing some of the complexity associated with the equations for physical processes, or by reducing the spatial and temporal resolution. Global weather models are designed to maximise spatial coverage, but some important small-scale physical processes may not be well represented, notably, convective processes and orographic processes (hills and mountains) that are nevertheless important drivers of localised, high-impact weather events. Limited-area models such as the Met Office's UK weather model which uses a 1.5km grid is capable of resolving many of these important processes (see image below) but are too expensive to run over a larger area (for example, over the whole of Europe). AI models, such as FastNet now offer the possibility of combining the benefits of large-scale global NWP and high-resolution limited area models within the same model.
- **Representing uncertainty through the use of ensembles**
  The Met Office aims to migrate weather forecasts to *ensemble* mode, where multiple possible future realities are produced to create an ensemble of outcomes that allows us to assess the range of impending weather. AI is particularly attractive in this context as it offers the possibility of producing vast numbers of possible forecasts with relatively little computational cost – a potential major benefit of AI for weather forecasting. Together the Alan Turing Institute and Met Office will explore how we can produce rapid, cost effective and optimised ensemble weather forecasts. The ensemble produced needs to accurately represent the real weather by being skilful and reliable; so that when we say there is a 90% chance of rain, it really does rain 9 times in 10!



Comparison of output from the Met Office's Global Model (left) and UKV (right) for precipitation (top) and 10m wind speed (bottom) during Storm Kathleen on the 6 April 2024.
The high-resolution 1.5km grid-spacing used in the UKV model can capture high-intensity convective events (b) and the influence of small-scale topographic features including abrupt mountains and coastlines (b and d), whereas the model with the coarser grid (a and c) cannot thereby limiting its effectiveness to inform detailed mitigation plans for industries including wind generation and agriculture.

Looking to the future, we do not anticipate the need for well-established physics-based simulation approaches to end any time soon.

Instead, we envisage the approaches running alongside and complementing one another maximising their combined strengths to provide accurate, fast, reliable, and trustworthy forecasts for the UK.

For example, physics-based models provide the critical physical-process based insight needed to understand performance and build trust in weather prediction. They are also important when considering events that are outside the data that has been used to train AI models, and they provide the training data used to create AI models (new, recalibrated datasets will be needed as our climate changes).

Complementing this, AI models are accurate, skilful and astonishingly fast (in some cases, tens of thousands of times faster than traditional methods). This speed delivers numerous benefits including more timely, accurate weather prediction at a significantly lower computation cost.

A bright forecast

The potential of AI in weather prediction is immense. By harnessing the power of data science and machine learning, we’re on the path to a future that draws together the strengths of both physics-based and data-driven modelling so that weather forecasts are faster, more accurate, detailed, and personalised than ever before.

The collaboration between the Met Office and the Alan Turing Institute is paving the way for this future, one forecast at a time.